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PHYS 362

Problem 1

a.) Volume doesn't change therefore there is no work done on the gas

b.) $\Delta E = Q + \cancel{W}^{0} = 0 \ : \ Q = 0 \quad \therefore \quad \Delta E = 0 + 0 = 0$

c.) $E = \frac{3}{2}NkT$: There is no change in energy $\therefore$ no change in temperature

d.) $E = \frac{3}{2}NkT - N\frac{N}{V}a$: The change in energy is positive $\therefore$ the change in temperature is negative

e.) $\left(\frac{\partial z}{\partial y}\right)_x = -\left(\frac{\partial z}{\partial x}\right)_y \left(\frac{\partial x}{\partial y}\right)_z$

$x = E,\ y = V,\ z = T$

$$\left(\frac{\partial T}{\partial V}\right)_E = -\left(\frac{\partial T}{\partial E}\right)_V \left(\frac{\partial E}{\partial V}\right)_T = -\left(\frac{\partial T}{\partial E}\right)_V \left[T\left(\frac{\partial P}{\partial T}\right)_V - P\right] \ : \ \left(\frac{\partial E}{\partial T}\right)_V = C_V \ \therefore \ \left(\frac{\partial T}{\partial E}\right)_V = \frac{1}{C_V}$$

$\therefore$

$$\boxed{\left(\frac{\partial T}{\partial V}\right)_E = -\frac{1}{C_V}\left[T\left(\frac{\partial P}{\partial T}\right)_V - P\right]}$$

f.)

i.) $T\left(\frac{\partial P}{\partial T}\right)_V = T \cdot \frac{Nk}{V} = \frac{NkT}{V} = P \ : \ T\left(\frac{\partial P}{\partial T}\right)_V - P = P - P = 0$

$\left(\frac{\partial T}{\partial V}\right)_E = -\frac{1}{C_V}(0) = 0$: $\boxed{\left(\frac{\partial T}{\partial V}\right)_E = 0 \text{ For ideal gas}}$ $\quad \Delta T = 0$

ii.) $\left(P + \frac{N^2}{V^2}a\right)(V - Nb) = NkT \quad \therefore \quad P = \frac{NkT}{(V-Nb)} - \frac{N^2 a}{V^2}$

$\left(\frac{\partial P}{\partial T}\right)_V = \frac{Nk}{(V-Nb)} \ : \ T\left(\frac{\partial P}{\partial T}\right)_V - P = \cancel{\frac{NkT}{(V-Nb)}} - \cancel{\frac{NkT}{(V-Nb)}} + \frac{N^2 a}{V^2}$

$$\boxed{\left(\frac{\partial T}{\partial V}\right)_E = -\frac{1}{C_V}\left(\frac{N^2 a}{V^2}\right) < 0 \text{ For Van der Waals}}$$

ΔT decreases as V increases

Problem 2

a.) $PV = NkT$: $E = \frac{3}{2}PV$ $\therefore$

$$\boxed{P = \rho kT \ , \ E = \frac{3}{2} P \frac{N}{\rho}}$$

: Volume and Energy are extensive because they can both be added with a two part system

b.) $P = \frac{NkT}{(V-Nb)} - \frac{N^2 a}{V^2}$, $E = \frac{3}{2}NkT - N\frac{N}{V}a$ $\therefore$

$$\boxed{P = \frac{NkT}{(N/\rho - Nb)} - \rho^2 a \ , \ E = \frac{3}{2}NkT - N\rho a}$$

: Volume and Energy are extensive because they can both be added with a two part system

Problem 3

$$dS = dS_A + dS_B \quad : \quad T = \left(\frac{\partial S}{\partial E}\right)^{-1}_{V,N} = \left(\frac{\partial E}{\partial S}\right)_{V,N} , \quad T_A = \left(\frac{\partial S_A}{\partial E_A}\right)^{-1}_{V,N} , \quad T_B = \left(\frac{\partial S_B}{\partial E_B}\right)^{-1}_{V,N}$$

$$dS = \left(\frac{\partial S_A}{\partial E_A}\right)^{-1}_{V,N} dE_A + \left(\frac{\partial S_B}{\partial E_B}\right)^{-1}_{V,N} dE_B \quad : \quad dE_A = -dE_B$$

$$dS = \left(\frac{\partial S_A}{\partial E_A}\right)^{-1}_{V,N} dE_A - \left(\frac{\partial S_B}{\partial E_B}\right)^{-1}_{V,N} dE_A \quad : \quad dS = \left[\left(\frac{\partial S_A}{\partial E_A}\right)^{-1}_{V,N} - \left(\frac{\partial S_B}{\partial E_B}\right)^{-1}_{V,N}\right] dE_A$$

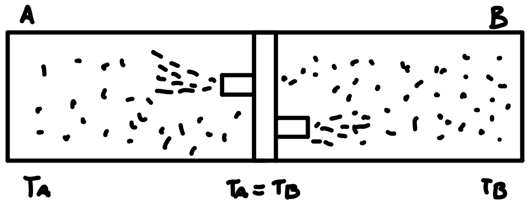
$$dS = \left[\frac{1}{T_A} - \frac{1}{T_B}\right] dE_A \longrightarrow \left[\frac{1}{T_A} - \frac{1}{T_B}\right] \Delta E_A \geq 0 \quad \therefore \quad \frac{1}{T_A} - \frac{1}{T_B} \geq 0$$

$\frac{1}{T_A} - \frac{1}{T_B} \geq 0 \longrightarrow$ if $T_A > T_B \therefore \Delta E_A < 0$
if $T_A < T_B \therefore \Delta E_A > 0$

Thus Energy flows from warmer to colder

Problem 4

a.)



b.) $dS = dS_A + dS_B$: $P = T\left(\frac{\partial S}{\partial V}\right)_{E,N}$

$$dS = T_A\left(\frac{\partial S_A}{\partial V_A}\right)_{E,N} dV_A + T_B\left(\frac{\partial S_B}{\partial V_B}\right)_{E,N} dV_B : \quad dV_A + dV_B = 0 \quad \therefore \quad dV_A = -dV_B$$

$$dS = T_A\left(\frac{\partial S_A}{\partial V_A}\right)_{E,N} dV_A - T_B\left(\frac{\partial S_B}{\partial V_B}\right)_{E,N} dV_A \quad : \quad dS = \left[T_A\left(\frac{\partial S_A}{\partial V_A}\right)_{E,N} - T_B\left(\frac{\partial S_B}{\partial V_B}\right)_{E,N}\right] dV_A$$

$$dS = (P_A - P_B)\,dV_A \longrightarrow (P_A - P_B)\Delta V_A \geq 0 \quad \therefore \quad P_A - P_B \geq 0$$

$P_A - P_B \geq 0$: if $P_A > P_B \therefore \Delta V_A > 0$
if $P_A < P_B \therefore \Delta V_A < 0$

Thus volume of the higher pressure system must increase as they approach equilibrium.

Energy could be transferred. At the same temp it does not matter. One gas does work on the other.